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East Europe Report

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ALBANIA

ACHIEVEMENTS, PROSPECTS IN FIELD OF PHYSICS

Tirana BULETINI I SHKENCAVE TE NATYRES in Albanian No 4, Oct-Nov-Dec 81 pp 3-6

[Article by S. Kuneshka and P. Skende: "Physics in Our Country, Achievements and Prospects"]

[Text] Before the liberation, one could not speak at all about the development of the physical sciences and of the other natural sciences.

In the level which physical sciences have reached today, we see embodied the great and farsighted work of the party to form the scientific culture of the country on the basis of the Marxist-Leninist concept of the most massive assimilation with high social effectiveness. The bases of the present level of physics were laid having in mind the concern for cultivating, first of all, a strong training in physics and mathematics in the schools and for treating physics as one of the major formative subjects.

The creation of special physics and mathematics education, up to the fifth year of physics, by the Pedagogical Institute ensured to the country the source of the very necessary cadres in this field. These cadres worked and are working to elevate physics to a higher qualitative level in the other specialized areas; they formed the first nucleuses of good research work in the field of this science and are helping us now to take care of postgraduate physics and mathematics studies.

In the search for good scientific research work in the field of physics, the first tests in the years 1960-1970 were carried out in the field of the study of radioactivity of mineral waters and of the physical characteristics of materials of the country in accordance with the material base available and with the requirements of applied science mainly in the area of geology. During the same 10-year period, theoretical physics concentrated mainly in the field of teaching and in other modest works in the field of solid-state physics also made some first advances.

The objectives for the development of nuclear physics in our country were set in the years 1964-1967. This made it possible in 1970 to create the laboratory of nuclear radiation at the Faculty of Natural Sciences, as an experimental center equipped especially for nuclear work; 1 year later, this center was converted into the Institute of Nuclear Physics at the University of Tirana.

In the 10-year period of 1970-1980, a number of important events took place in the science of physics, just as in our entire science in general, stemming from the far-seeing decisions and guidelines of the party for the development of the technical and scientific revolution, which are formulated in a synthesized manner in the directives of the Seventh Party Congress that "scientific research work and studies be converted into a general method that will penetrate and precede every action and will effectively aid in solving the current and future problems of the building of socialism and the defense of the fatherland."

Now, two main routes of research in physics have been outlined clearly in our country: solid-state physics and applied nuclear physics, directed mainly by the departments of physics of the university and by the Institute of Nuclear Physics attached to the Academy of Sciences. A great number of groups of physicists and specialists in other fields, working in the enterprises and institutions everywhere in the fatherland, are collaborating with these two main centers.

Recently, a center for electronic microscopy has been set up at the Faculty of Natural Sciences and has put an effective means of research work in the service of solid-state physics and of the other branches of science.

In the field of solid-state physics, the departments of physics have achieved results of important practical values such as the perfection of the method for the extraction of selenium of high purity and the production of semiconductor plates. They have studied the characteristics and the possible use of Tropoje quartz in the formation of silicium and of ferrosilicium in cooperation with the Institute of Mechanical Studies and Designs; they have enlarged and expanded their research work and have managed to construct a pilot-plant for the production of technical silicium; and have terminated the study of the physical, chemical and technological characteristics of silicium-bearing raw materials with valuable data for the glass industry.

Also, in the field of solid state physics, the departments of physics have studied the mechanical-physical characteristics of copper of our country and the problems of the structure of the formation by stages of metals and alloys, the presence of internal pressure, the textures and so forth, using X-ray structural analysis and microscopic-electronic analysis and the problem of the possibility of producing, in the country, carbographite materials of interest to the printing industry and transportation. They have also examined other problems of applied physics such as the use of ultrasound, especially in biological and agricultural sciences and the elimination of negative phenomena of static electricity in the textile and paper industries and so forth. They have carried out an important work in methodical and scientific studies such as these which are linked with the improvement of the effectiveness of the teaching and scientific processes through audio-visual techniques and so forth.

In the field of theoretical physics, the departments of physics have carried out and are carrying out works such as: the explanation of many phenomena in crystalline liquids and the molecular crystals of the ellipsoidal glass condition, the study of specimens in the electric and magnetic fields on strata of

petroleum and gas, the study of the use of the theory of groups in some problems of the theory of the field, the study of the problem of determinism in quantum mechanics and the evolution of views on the structure of matter and so forth.

Now that the center of gravity of the research work in the field of nuclear physics has been moved to the Institute of Nuclear Physics of the Academy of Sciences, the departments of physics are continuing their collaboration with the institute and are working on some aspects such as the monitoring of the radioactivity of the atmosphere through the timed distribution of global beta activity in the atmospheric precipitations and deposits, and the study of radioactivity of mineral waters.

In the field of nuclear physics, during the 10 years of activity of the institute, some noticeable results were achieved in regard to putting the methods of nuclear physics in the service of our economy and science. Thus, isotopic trackers were widely used in industry for checking the drilling columns in oil wells; in agriculture, for checking the process of fertilizing and of rational microfertilizing; and, in hydrology, for the measurements of debits, filtrations and movements of subterranean and surface waters, as well as of the dynamics of the movement of sediments in port construction. In the sector of medicine, the compositions indicated for diagnosis were used, perfecting work methods and techniques such as radioimmunoassay and scintigraphy.

Studies have been done on the mutagenic effects of gamma radiation on the kinds of plants which are of interest for our country. With the participation of or under the direction of the research institutions and the agricultural experimentation centers, radiation has been used in small quantities for the stimulation of seeds before sowing and data have been obtained about the quantities which are most favorable for preventing the sprouting and spoiling of agricultural products, such as potatoes, onions and so forth.

During the study of the effect of radiation, conclusions of practical value have been obtained on the improvement of the physical characteristics of polyethylene through electronic radiation.

The development of analytical methods and techniques holds an important place in the scientific activity of the institute. In this field, we can mention the development of such things as the spectrometry of gamma rays and X-rays, mass-spectrometry, the recording of low levels of radiation, the problems of the joint action between radiation and substance, digital methods of processing spectra and so forth.

Now, the institute is working extensively on neutronic activation, with rapid and thermal neutrons, using isotopic sources and neutron generators; the method of X-ray fluorescence with semiconductor detectors has been successfully put into operation. The institute has put the method of determining the absolute age of rocks (K-Ar method) in the service of geology, has used scintillators and fluids in radiometry and has assimilated the method of attenuating isotopes.

In harmony with the development of experimentation in physics, now a relatively good level has been assured in the field of nuclear electronics so as to handle only the incorporation of contemporary electronic technology using highly integrated circuits but, also, to design in the country nuclear apparatuses for measuring and controlling, such as level and density measures for melting in closed containers, radiometers of simple types of gamma ray detectors.

The Eighth Plenum of the Central Committee of the Albanian Workers Party and the Seventh Five-Year Plan open new prospects for and mark a new step on the road to the quantitative improvement of physics in our country. Thus, the rapid development of industry, especially of the mineral processing, metallurgical and machine industries, assigns to solid-state physics the task of making a qualitative leap forward in the field of experimentation and of theoretical generalization. A further increase in the use of nuclear methods and the invigoration of nuclear electronics are foreseen in the field of nuclear physics. Other new elements are the tasks for the development of laser technology in the service of the economy and defense. Also, there are plans to develop biophysics in our country. Neutron physics, as one of the most important branches of nuclear physics, will progress on the road of its invigoration and stabilization, on its own direction, until the construction of the experimental reactor.

It is the task of all our physicists, justifying the confidence bestowed on them by the people and the party, to elevate the physical sciences to an increasingly greater level and make of them an effective means for the development of the other theoretical and applied sciences in our country.

As all our workers, our physicists, too, are looking forward to meeting the 40th anniversary of the founding of the Albanian Workers Party and the Eighth Party Congress with new successes. Even greater are the tasks undertaken by our physicists, for the future, for the further development of the physical sciences and for the expansion of the technical and scientific revolution in our country.

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PROBLEMS OF DISCRIMINATION IN REGIONAL ANALYSIS

Budapest DEMOGRAFIA in Hungarian No 1, 1980 pp 42-51

[Article by Guillaume J. Wunsch, professor at the Demography Department of Louvain University]

[Text] Discriminational Analysis

Let us consider n number of regions, characterized by a dependent variable (e.g., the estimated value of the rough mortality rate, taken by some standard method) and m number of regions, characterized by independent variables $X_1, X_2, \cdots, X_m$ (e.g., environmental factors influencing mortality). Let us assume that by an appropriate classification (grouping) process regional subgroups are generated from the n number of regions, based on the affinity of their mortality rates; from these, subgroup A has n_1 regions with a low mortality rate, subgroup B has n_2 regions with an average (i.e., medium) mortality rate, and subgroup C, n_3 regions with a high mortality rate. The regions can, of course, be grouped according t their area characteristics or other indicators, based on their affinity, but the criterion used for the classification is not considered here. This topic is regarded as external to the scope of our study.

The important problem is to establish independent variables from X_m, which best explain the differences between the given subgroups of the regions and play the most significant role in them. A possible approach is to regard the subgroups of the regions as dummy variables (Reference 3, Chapter 6; Reference 9, Chapter 3) and submit the relationship of these variables and the X_i coefficient variables to multiple regression tests. If we have k subgroups, which are all dummy variables, the correlation analysis between the k-number Y value and the m-number X value of the key variables (coefficient variables) is performed using the method of so-called canonical correlation analysis (Reference 1, Chapter 12), which is an extension of the case when there is more than one Y variable.

The problem in question, however, can also be solved by discriminational analysis; in this case, the goal is to find that linear combination of variables X_m which can be optimally differentiated between the subgroups of the regions. Discriminational analysis can be regarded as that extension of factor analysis during which those orthogonal components are chosen which delimit the regions in view of their classification to groups (Reference 2,

Chapter 9); however, it can also be regarded as a multivariate normal population classification procedure, whose variance and covariance matrices are equal (Reference 1, Chapter 6). The orthogonal components are called discriminational functions. The first discriminational function maximizes the value of the variance between the groups, relative to the variance within the groups; one of the consequence of this is that the differences between the groups will be large compared to the differences within the groups. After the first discriminational function is formed, the second one can be formed based on the consideration that the second one must be orthogonal to the first one (same as in factor analysis); the process is continued until the last orthogonal discriminational function is generated: it can be easily seen that k-1 discriminational functions are generated, if the number of regions is k (if $k-1 < m$, m is the number of X variables). To express this more formally (Reference 2, pp 246) let A be the square deviations of the group average and overall average of variables X_m and the matrix containing the sum of their series between the groups; moreover W will indicate the matrix which contains the X_m-variable square deviations from the group average and the sum of their series within the groups. Let υ be the vector of those weights which maximize the proportion of square sums between the groups for the square sums within groups; i.e., when equality $\lambda = \frac{\upsilon' A_\upsilon}{\upsilon' W_\upsilon}$ is satisfied. It can be shown by differentiation that the maximum value of $\lambda(\lambda_1$ and the connected υ_1 vector of the weights) corresponds to the largest eigen value (and its connected vector) of the characteristic equation $(W^{-1} A - \lambda I)\ \upsilon = 0$, where I is a unit matrix. Using the formal language of vector algebra, the first discriminational function can be expressed as $y = \upsilon_1' x$, where x is the vector of standardized key coefficients (coefficient variables). The second discriminational function can be expressed in form $y = \upsilon_2'\ x$ and formed after the maximization of λ, taking into account that the second function must be orthogonal to the first one. This process can be continued until the W^{-1} A eigen value becomes zero; if $k-1 < m$, rank A or W^{-1} becomes k-1, i.e., it becomes identical to the rank of matrix A, and thus k-1 number of discriminational functions can be formed from the characteristic vectors of the equation.*

For every discriminational function (standardized discriminational function coefficient), vector υ of the weights indicates the contribution of the individual variables to the value of the functions; the larger they are (independent of their sign), the more discriminating are the connected variables. Based on this, the variables that best "explain" the differences between the groups can be selected. The coefficients generated for the first discriminational function (same as in factor analysis) supply the values of the key variables; the coefficients satisfying the second discriminational function become the key variables after the "contribution" of the first discriminational function is subtracted.

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* If the number of the groups does not exceed that of the variables ($m \gtrsim k-1$), the maximum number of the discriminational functions is m, i.e., this number becomes equivalent to the number of variables.

Let us assume that there are new observational results available for variable X_m. The second task of the discrimination, in this case, is the classification of the observational results to the most appropriate group. Classification "marks" can be generated (computed) for each group; the new observational data is relative to the group with the highest "mark," i.e., the group at the shortest distance from the observation. If the variables are correlated (collinear), it is advisable to use the Mahalanobis distance index (Reference 7, Chapter 18), since it is better than the Pythagoras distance index. The Mahalanobis square distance between vectors x_i and x_j can be determined by the $(x_i - x_j)' \; ^{-} (x_i - x_j)$ formula, where Σ is the variance - covariance matrix of the complete set of variables.* The Mahalanobis distance index is used throughout this treatise.**

Aggregation and Multicollinearity

Interdependent variables are called multicollinear. As we know, in econometrics, multicollinearity influences the accuracy of results generated by regression analysis: the true significance (explanatory power) of original variables remains hidden if they are strongly interrelated. One of the objectives of this study is the discovery of the effect of multicollinearity between key variables (coefficient variables) in discriminational analysis.

The second objective of our study is to shed light on the effect of aggregation on the discriminatory power of X_m variables. As we know, aggregation may become in some cases a source of "ecological errors" in regression analysis, since aggregation not only results in a significant increase in correlational connections but--in the case of contextual and ecological effects--can also hide the most significant relations (e.g., see Reference 6, pp 190-193).

The effect of aggregation and multicollinearity on discriminational analysis results will be examined with the aid of simulation. Let us consider a random number of administrative regional units (e.g., 56 of them) for which the analytical correlation of X_m variables is fully known. The 56 units (subregions) are grouped to 8 larger units via systematical or random classification. We may start with our previous example: the subregions may, for instance, be classified based on their mortality rate; discriminational analysis involves the X_m key variable (coefficient variable).

The 56 subregions are then grouped to 8 regions (systematically or randomly) and discriminational analysis is extended to these larger units (regions), after grouping them according to the average mortality rate in the given

* Other distance indexes are used as well, but, in general, the use of the Mahalanobis index is recommended (see Reference 4, pp 131-163).

**The Mahalanobis distance criterion can also be formed by computing the logarithm of the likelihood portion of the normal case and making it equal to one. See Reference 7, pp 260-261.

regions. Then the results of analysis based on the grouped data are compared to those based on the original (ungrouped) data.

The discriminational analysis program was generated based on version H of the SPSS program package (Reference 5, Chapter 23) and the stepwise selective and stepped Mahalanobis distance criterion was used. To check the results, another, the Rao generalized distance criterion* was used and the results were found to be very close to those obtained by the SPSS program package (except for one, which will be discussed later).

Model A: Perfect Multicollinearity

The model is based on the following relationship:

$$Y = X_1 + 20 \qquad X_1 \text{ varies between } 1 - 56$$
$$X_2 = 10\ X_1$$
$$X_3 = 57 - X_1$$

The three key coefficients (X_1, X_2 and X_3) are linearly related. The 56 subregions are grouped in two classes. Classification to model AA is systematical: 28 low-value subregions end up in region A, and the remaining 28 in B. Classification to model B is random.

Models AC and AD are based on regions: the 56 subregions were grouped systematically and randomly to 8 regions. In models AC, the grouping of subregions was based on the values of variable Y; after that, the eight regions were divided into two parts based on variable Y, i.e., they were grouped to class A and B: the values of variable Y and X_m are generated according to the data in Table 1.

Table 1. Average Values of Variables by Regions (AC Model)

Class	Region	Y	X_1	X_2	X_3
A	A1	24	4	40	53
	A2	31	11	110	46
	A3	38	18	180	39
	A4	45	25	250	32
B	B1	52	32	320	25
	B2	58	38	380	19
	B3	65	45	450	12
	B4	73	53	530	4

In the case of model AD, the grouping of the subregions to two classes was done randomly. Thus the classification is identical to the procedure used during the two-step sampling procedures: based on a different random classification different results are obtained. The average values relative to the eight regions are formed according to the data in Table 2.

*This program may be found in the statistical package of the North Carolina State University.

Table 2. Average Values of Variables by Regions (AD Model)

Class	Region*	Y	X_1	X_2	X_3
A	A1 (4)	55.5	35.5	355	21.5
	A2 (12)	42.3	22.3	223	34.7
	A3 (5)	42.8	22.8	228	34.2
	A4 (9)	60.9	40.9	409	16.1
B	B1 (8)	42.9	22.9	229	34.1
	B2 (7)	38.9	18.9	189	38.1
	B3 (2)	53.5	33.5	335	23.5
	B4 (9)	45.7	25.7	257	31.3

* The number enclosed in parentheses indicate the number of subgroups (subregions).

Unlike in regression analysis, during which perfect multicollinearity renders the inversion of the X'X matrix of the key coefficients (coefficient variables) impossible, it is possible to compute the orthogonal discriminational functions in this case. The application of the stepwise Mahalanobis criterion in the case of model AA results in the selection of only one (X_2) key coefficient (coefficient variable) by a nearly perfect discrimination between the subregions. This same process makes possible the discovery of a key variable (the X_3 coefficient variable) in model AB which is based on the random classification of the subregions; the discrimination, however, in this case is very weak; the value of the canonical correlation coefficient of the discriminational function and the coded class variable of the dummy variable is only 0.19 (and statistically is not different from zero, $P = 0.05$).

If we consider aggregated regions, however, in model AC, X_2 is the only key variable (coefficient variable) (the value of canonical correlation coefficient is 0.998) and no variable is selected in model AD based on random classification. Thus, the stepwise Mahalanobis criterion takes into account the fact of multicollinearity and selects only one key variable (coefficient variable); furthermore, the random nature of the classification was also demonstrated, and thus the application of the method offers the opportunity to avoid erroneous conclusions.

Model B: Imperfect Collinearity

In model A, the data were randomly obscured by the generated "white noise" in order to get rid of the perfect multicollinearity between variables X_m.* At the same time, the collinearity between the key variables (coefficient variables) remained strong (0.98, or higher).

Model BA resembles model AA in certain ways: the classification of 56 subregions to 2 classes is based on their Y variables. When the stepwise procedure is used, only one variable (X_3) is selected, and the value of the canonical correlation coefficient is 0.855, i.e., 14 percent less than in model AA

*This is not the case if the so-called direct method of the SPSS program is used: based on this criterion, two perfect collinear variables are selected. Thus, it is simpler to apply the stepwise Mahalanobis distance criterion.

because of the white noise. In spite of this high discriminational level, the classification of the original variables is done with rather poor results: from 56 subregions, 25 are incorrectly classified! Using the same data, the SAS program classifies only 3 subregions incorrectly out of 56; classification marks were calculated for all 56 subregions, and this approach was used for the classification of original data. Using this procedure, only one subregion was incorrectly classified; thus it appears that the application of the SPSS program (based on the probability of the grouping) produces faulty results in certain situations, such as the one mentioned.

In model BB, the 56 subregions were randomly divided between the 2 classes. No variable was selected that could have been regarded as a discriminational variable between the two classes.

Models BC and BD are based on the repeated aggregation of the subregions. In the case of model BC both aggregation and classification are systematical, the same as in model AC. In the case of model BD (as in model AD) both aggregation and classification were randomly performed. In the case of model BC, two variables (X_1 and X_2) with approximately equal discriminational power were selected, in spite of the significant multicollinearity between the X_m variables. The value of the canonical coefficient increased from 0.855 (model BA) to 0.937 (model BC) as a result of aggregation. Fortunately, in the case of random model BD, no variable was selected.

Model C: Random Data

In this model, all X_m variables were randomly generated. The classification and aggregation of subregions were also randomly performed. In the case of model CA (all 56 subregions), variable X_3 was selected as a key variable; the discriminational force, however, is almost negligible (the value of canonical correlation coefficient is 0.14 and statistically is not different from zero, $P = 0.05$). In the case of model CB (8 regions), the stepwise operation did not select any variable. Once again, it has been demonstrated that no significant discriminational variables can be obtained by random classification.

Model D: Contextual Effects

Contextual and ecological effects were also introduced to this model. Data were selected for 56 regions (divided into 8 groups) in a manner to render the relationships between the variables contrary to the connections between the groups. Figure 1 shows as an illustration the connection between the Y dependent variable and the X_3 independent variable in this case.

The 55 subregions were grouped to 2 classes: for model DAA, the grouping was random and for model DAB, systematical; the 28 values of variable Y were assigned to class A and its 28 highest values, to class B. In the case of random classification (model DAA), the stepwise Mehalanobis criterion did not result in the selection of any variables. In the case of model DAB, variable X_3 was the only discriminational variable; the canonical correlational coefficient was equal to 0.855. During the reclassification process, the application of the SPSS program package again produced faulty results (as in the

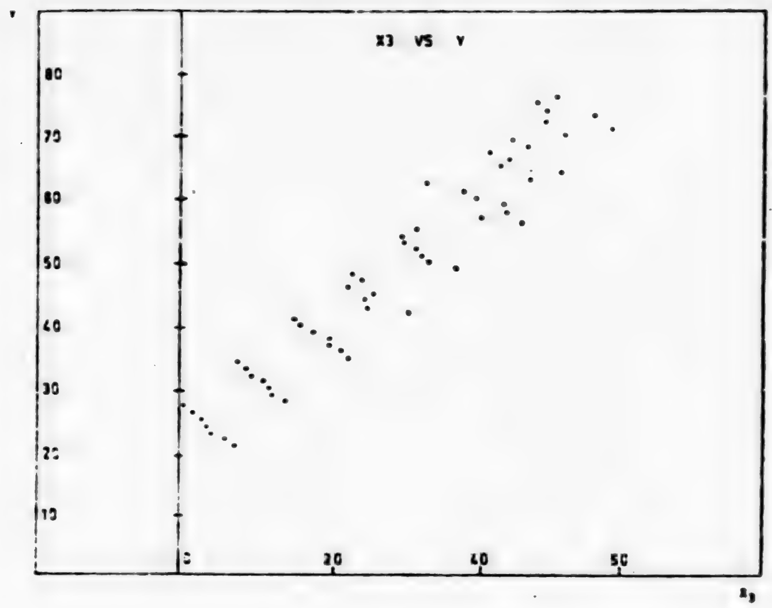

Figure 1. Relationship Between Y and X_2 (original data)

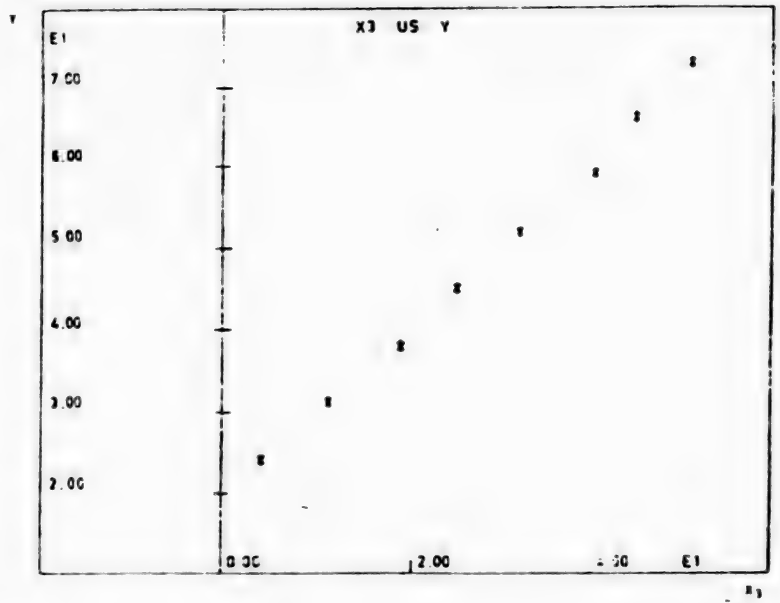

Figure 2. Relationship Between Y and X_3 (Aggregated Data)

case of model BA), instead of 28 subregions only 7 were assigned to class B. If the subregions are classified according to their class "marks" instead of their group association likelihood, only one subregion will be incorrectly classified. Thus, the conversion of class "marks" to group association probability is not allowed.

Model DB groups the 56 subregions to 8 regions which correspond to the 8 groups of model DA. Aggregation, in this case, results in the obscuring (hiding) of the relationship between the groups: as shown in Figure 2, only the connection (contextual effect) between the groups is visible following aggregation. In the case of model DAA, the classification is random; no discriminational variable is chosen. At the same time, systematical classification was used for model DAB; this brought about the selection of two discriminational variables (X_1 and X_2). It is interesting that during stepwise approximation (i.e., after the first step of the process), variable X_3 appeared to be the most discriminational; after the introduction of X_1 and X_2, however, the discriminational power of X_3 dropped drastically until variable X_3 disappeared (was struck) from the list of discriminational variables. The occurrence of this case is especially typical when the collinearity between the variables is very large, which results in the appearance of extraneous variables. In the current case, variables X_3 and X_2 are collinear to X_1, and thus discriminational analysis selects one more variable than necessary. The discrimination is excellent; the value of the canonical coefficient is equal to 0.934, and the classification of all occurring cases is proper. Thus, it is once again demonstrated that aggregation leads to the increasing of the canonical correlation coefficient, since this latter was a mere 0.855 for ungrouped data (model DAB).

Conclusions

The purpose of this study was to disclose the effect of data aggregation and that of multicollinearity between the variables on discriminational analysis. It has been demonstrated that aggregation leads to the increasing of the canonical correlation coefficient, as it increases the multicorrelational (i.e., determinant) coefficient value in multiple regression analysis. Thus high values of this coefficient do not always guarantee good discrimination. For that reason, this coefficient must be submitted in all cases to significance examination. Discriminational analysis never falls into the loophole of random classifications. The incorrect selection of the discriminational variable from randomly classified data does not occur either; either in the case of previously aggregated or for ungrouped data.

The elimination of extraneous variables resulting from multicollinearity can be rather well managed by the application of the Mahalanobis criterion. The discriminational variable still varies from model to model: thus the disclosure of fundamental connections cannot be regarded as appropriate (satisfactory).

In closing, it will be noted that the reclassification procedure of our data via the application of the SPSS program brought to our attention some problems: postclassification based on the classification "marks" produced better results than the classification procedure based on the likelihood of group association did.

Acknowledgements

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TUNABLE DYE LASERS AND THEIR APPLICATIONS

Debrecen LUMINESZENCIA in Hungarian 27-28 Aug 79 pp 21-45

[Article by B. Racz, Zs. Bor and L. Kozma, Attila Jozsef Science University, Experimental Institute, Szeged]

[Text] The close relationship between laser physics and luminescence research provides a good basis to summarize the functioning and typical applications of a special class of lasers, dye lasers. An ideal excitation light source for spectroscopic purposes would have sufficient power; a small bandwidth compared to the examined phenomenon would be well-directed (i.e., easy to handle from the optical viewpoint), suitable for the generation of short optical signals; and its wavelength could, if necessary, be easily changed. To complete the requirements, this light source should be inexpensive, if possible, and technically easy to handle.

Unfortunately, such a light source does not exist. If we limit our interest to the visible and near ultraviolet spectral range, dye lasers are a good approximation. Accordingly, dye lasers are extremely widespread and are used in a multitude of applications.

I. Functional Basis of Dye Lasers

By dye we mean those organic materials that contain chromophore groups and have strong absorption in the near ultraviolet, visible and infrared range. The chromophore group is a conjugated chain of carbon atoms with alternating single and double bonds. The longer the chain is, the larger the absorption wavelength. Only those materials can be considered lasers that, following absorption, return to their basic state via light emission; i.e., are fluorescent. As a result, of the several thousand dyes known, only about 500 can be used as an active agent of dye lasers.

The thermosystem of a typical dye can be seen in Figure 1. S_0, S_1, S_2 indicate single, and T_1, T_2 triple electron states. Resonance sublevels are indicated by thick lines, the expansion caused by the interaction with the solvent by thin lines, optical transition by continuous lines, and nonoptical by dotted lines. In the case of thermal equilibrium, the molecules are in state S_0 and distributed in the resonance sublevel according to the Boltzmann distribution. As a result of optical excitation, $S_0 \rightarrow S_1$, $S_0 \rightarrow S_2$ transitions

are produced as a function of the wavelength. Without $S_2 \rightarrow S_1$ transition radiation, S_2 lasts for 10^{-12} seconds (s). Fluorescence is created by the allowed transition, which typically lasts for 3.10^{-9} s. The equilibrium distribution in the resonance sublevel appears in about 10^{-12} s; thus the fluorescence spectrum is independent of the excitation wavelength. The dye laser operates between levels $S_1 \rightarrow S_0$.

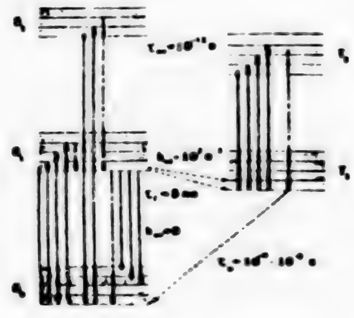

Figure 1. The Jablonsky The:mal System of Dyes

Although transition $S_1 \rightarrow T_1$ is illegal, its transitional probability is 10^7 s^{-1}. T lasts for 10^{-6} - 10^{-3} s; i.e., in the case of excitation longer than 10^{-6} s, T_1 may become well filled. Transition $T_1 \rightarrow T_2$ is also permissible and normally falls within the expected wavelength of the laser. Absorption $T_1 \rightarrow T_2$ may be a source of significant losses in the case of dye lasers generating pulses longer than 1 μs.

Let us examine closer the conditions for the appearance of optical amplification. Let a light beam of intensity I and frequency ν fall on a homogeneous material. Passing through a layer of thickness dx, its intensivity change can be expressed by the following form:

$$dI = -k(\nu) I dx \tag{1}$$

where $k(\nu)$ is the absorption coefficient of the material, which of course, depends on frequency. It is useful to transcribe $k(\nu)$ - t to $k(\nu) = N\sigma_a(\nu)$ for the dye molecules, where N is the concentration of the molecules and $\sigma_a(\nu)$ the absorption efficiency cross section. From the excited state, part of the molecules transits to the basic state via fluorescence, i.e., via spontaneous emission. This, however, is distributed over a 4Π solid angle; thus, its effect on the intensity of excitation beam I is negligible. Forced emission is much more important, since its frequency, phase, polarization and propagation direction agree with those of the excitation radiation. Taking into account forced emission, equation 1 can be expressed in the following form:

$$dI = -I dx[N_0\alpha_a(\nu) - N_1\alpha_e(\nu)] \tag{2}$$

where N_0 and N_1 are the concentration of the molecules in the basic and excited states and $\sigma_e(\nu)$ is the efficiency section of the forced emission.

The magnitude of the efficiency cross section $\sigma_e(\nu)$ is similar to that of the absorption efficiency cross section and falls in the fluorescence spectrum. Comparing equation 1 with 2, we set the following equation:

$$(\nu) = N_0\sigma_a(\nu) - N_1\sigma_e(\nu) \tag{3}$$

In the equilibrium state, $N_1 << N_0$ and thus $k(\nu)$ are positive; i.e., the material has absorption. Through sufficiently intense excitation, a significant percentage of the molecules may enter the excited state; quantity $k(\nu)$ can assume negative values in the fluorescence spectrum. From the physics viewpoint, negative absorption means amplification. To summarize, the dye solution becomes an optical amplifier through the effect of sufficiently intense excitation.

Let us examine next the behavior of a dye solution having optical amplification in a so-called resonator, which consists of two parallel flat mirrors with reflection R_1 and R_2. The amplification of the dye solution is characterized by the $\alpha(\nu)$ amplification coefficient, which is defined as -1 times the absorption coefficient. After passing through the dye solution, which has wavelength L, the I initial-intensity light has intensity $I\exp\alpha L$ (Figure 2). It is reflected from the mirror of reflection R_1 with $R_1 I\exp\alpha L$ and passes through the solution again, exiting with intensity $R_1 I\exp 2\alpha L$. It is finally reflected with $R_2R_1 I\exp 2\alpha L$ from the mirror of reflection R_2. Condition $I=R_2R_1 I\exp 2\alpha L$ must be satisfied in order to ensure that the intensity within the cavity is not reduced.

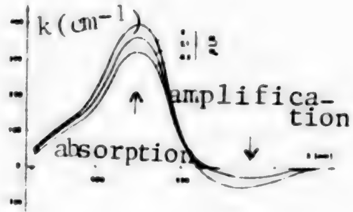

Figure 2. The Function of Absorption Wavelength in the Case of Various Excited State Population. Negative absorption is equivalent to optical amplification.

Forming the logarithm of the equation, the following expression results:

$$\alpha = \frac{1}{2L} \ln \frac{1}{R_1 R_2} \tag{4}$$

which is the condition for the self-excitation of the laser. If the amplification of the dye solution in the resonator exceeds the value defined by the four expressions, the setup will function as a laser.

II. The Structure of Dye Lasers

The excitation of dye lasers may be accomplished by another pulse-driven laser, flash tube or continuous operation laser. The structures of variously excited lasers differ from one another; thus, it is best to discuss them separately.

II. 1. Dye Lasers Excited by Pulse Lasers

Pulse lasers generate 10 kW to 10 MW pulses for 1 to 50 ns. If power of this magnitude is focused on a 1 cm x 0.3 mm line, the $\alpha(\nu)$ amplification factor may reach a value of 1 to 10^{-1} cm, and the condition of self-excitation[4] can be easily satisfied. Excitation by nitrogen laser will be demonstrated next, since this is the most commonly used method; the observations are valid for other cases as well.

The nitrogen laser radiates a light pulse at 337.1 nm in the near ultraviolet range, with a power of 0.1 to 3 MW for a period of 5 to 10 ns and a repetition frequency of 0 to 500 Hz. Its technical simplicity and relative cheapness are the real reasons for its popularity.

There are several methods for the experimental arrangement of dye lasers; the so-called transversal arrangement will be discussed here. The beam of nitrogen lasers is focused by a cylindrical lense on a 1 x 1 cm transparent cuvette. The concentration of dye solution in the cuvette is chosen to have a 30^{-1} cm absorption coefficient at the wavelength of the excitation. This way, an 0.3 mm x 0.3 mm x 10 mm amplifier medium is created. To create a laser with a less than 10 nm bandwidth, the resonator loss somehow must be made a function of the frequency. In the simplest method one of the usual resonator mirrors must be transformed into a reflection grid, as shown in Figure 4. Such laser resembles a Littrow monochromator.

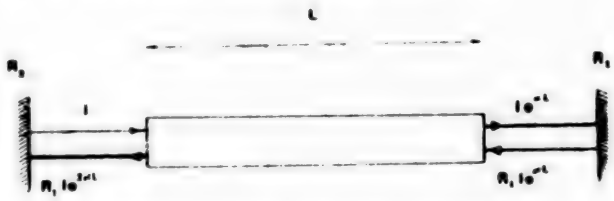

Figure 3. Power Flow Relationships in the Resonator of the Laser.

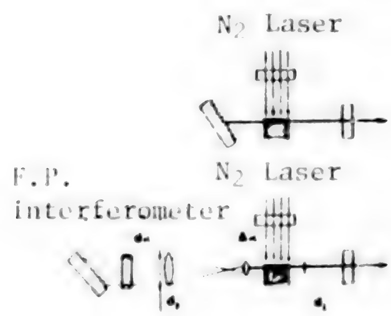

Figure 4. The structure of a Tunable Dye Laser Excited by Laser N_2. Tuning is accomplished via rotating the grid.

Bandwidth can be further reduced in the arrangement shown in Figure 4 by placing a telescope between the cuvette and the grid. If the angle magnification of the telescope is N, the bandwidth is reduced by 1/N.

The frequency dependence in the resonator can be further increased by placing a Fabry-Perot interferometer between the telescope and the grid (Figure 4b). With careful design, in the setup shown in Figure 3b, the Fourier transformation

limit may be approximated, which is expressed as $\Delta t \cdot \Delta\nu \approx 1$, where Δt is the time span of the pulse and $\Delta\nu$ the bandwidth of the frequency. Assuming t = 10 ns, the attainable bandwidth is 10 MHz. Most significant radiation data of dye lasers excited by pulse lasers follow:

efficiency relative to excitation energy: 5 to 25 percent
divergence: 1 to 5 mrad
bandwidth: 0.0005 to 10 nm
tunable range: 350 to 1100 nm
output pulse power: 10 to 200 kW
pulse duration: 4 to 7 ns

According to our latest research, tunable 10^{-10}- 10^{-11} s pulses can also be generated by due lasers excited by N_2 lasers in a special setup.

II. 2. Dye Lasers Excited by Flashtubes

Excitation by lasers can be rather efficient, as high as 25 percent, but exciter lasers have inherently low efficiency. Thus, the resulting efficiency is low. Flashtubes converting electric energy into light with about 30 percent efficiency serve as an improvement in efficiency. They radiate between the ultraviolet and infrared spectrum; the wide absorption band of the dye uses part of the radiation. The light pulse of flashtubes is generally between 1ms to 100 μs; in this case the loss-causing effect of the triple states is no longer negligible. Laser operation longer than 1 μs can hardly be expected if the τ_T decrease is not handled. For this reason, a short pulse-duration flashtube must be used for excitation; this is best achieved by increasing the voltage and the resonance frequency of the whole supply circuit. In practice, there are two popular excitation methods: In one case, a linear flashtube is used in an elliptical reflector; in the other, the flashtube coaxially surrounds the cuvette containing the dye (Figure 5). All methods discussed in the previous chapter can be used for tuning. The efficiency of dye lasers excited by flashtubes can be between 0.5 to 1 percent; output power is much larger than in the case of excitation by a laser. Soviet researchers describe the generation of 400-J power pulses for 10 μs pulse duration. In addition to triple absorption, the ultraviolet and infrared radiation of flashtubes also causes difficulties. One starts a photochemical reaction, while the other heats up the solution, which changes its refractive index. The concentration of active material decreases with the photochemical reactions, while the changing of the refractive index distorts the wave front in the resonator.

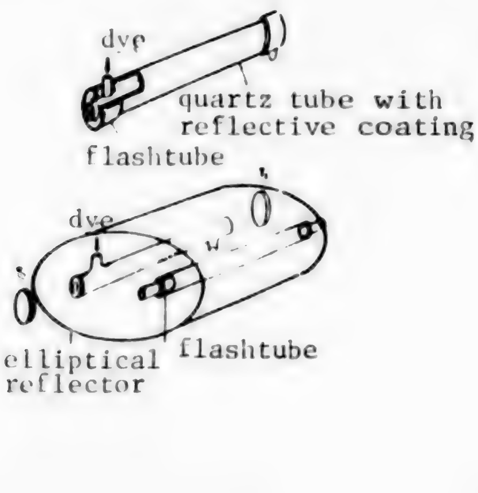

Figure 5. The Structure of a Dye Laser Excited by a Flash Tube.

Parameters of lasers excited by flashtubes are:

efficiency: 0.5 to 1 percent
bandwidth: 10^{-5} to 10nm
power: 10 mJ to 400 mJ
tunable range: 380 to 800 nm
pulse duration: 1 to 10 μs

II. 3. Continuous Operation Dye Lasers

There are two major difficulties in designing continuous operation lasers. First, the power of continuous operation exciter lasers is 1 to 10 W; i.e., 10^3 to 10^6 times smaller than that of pulse lasers. Consequently, it is difficult to satisfy the prerequisites of self-excitation.[4] Second, because of the effect of continuous excitation, the triple state of dyes becomes filled and the $T_1 \rightarrow T_2$ absorption hinders the operation of the laser. These two difficulties can be alleviated by the method in Figure 6.

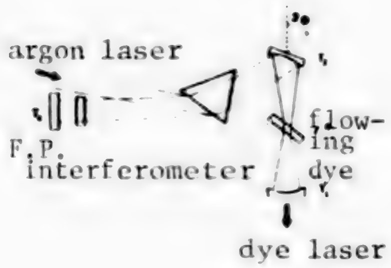

Figure 6. The Structure of a Continuous-Operation Dye Laser.

The beam of the 1 to 10 W average power argon laser is focused by mirror T_2 on the 0.3-mm wide dye solution stream, flowing at approximately 10 m/s speed. The diameter of the focused beam within the liquid stream is about 30 μs; thus the excitation-efficiency density is 10^5 to 10^6 W/cm^2, which produces sufficient amplification. Based on these data, it can easily be seen that the average dye molecule is excited for about 3 μs, after which it exits from the resonator of the laser; its triple absorption does not cause any losses. Thus, the laser has continuous operation, as far as the user is concerned, and pulse operation with a 3-μs pulse length, as far as the molecule is concerned. The prism placed in the resonator and the Fabray-Perot interferometer assure a narrowing of the bandwidth and handle tuning. Typical data of continuous dye lasers are:

efficiency: 10 to 30 percent (relative to the exciter laser)
bandwidth: 100 Hz to 1 GHz
tunable range: 400 to 800 nm

III. Applications of Tunable Dye Lasers

The appearance of tunable dye lasers created a qualitative change in spectroscopy. The sensitivity and resolution of methods increased significantly; the examinable wavelength range became wider. It became possible to study processes shorter than 10^{-12} s. The multifront and nonlinear phenomena during

the application of large excitation densities provide insights to fundamentally new characteristics of the material. Short-duration excited states can also be studied by relatively simple methods. Next we shall demonstrate by examples the new opportunities offered by dye lasers (without striving for completeness) and mention applications important for the economy and other branches of science.

III. 1. Increase in Sensitivity

III. 1. 1. Spectroscopy in a Resonator

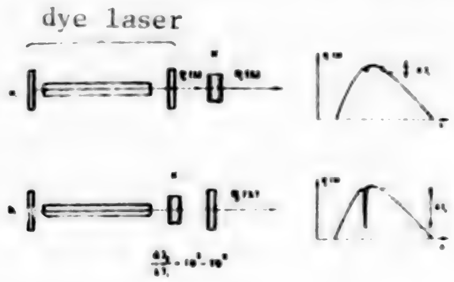

Figure 7. The Principle of Spectroscopy Within a Resonator

The principle of the system is illustrated in Figure 7. Cuvette K, which contains a material possessing weak absorption at a given wavelength, absorbs a small ΔI_1 portion of radiation $P_0(\lambda)$ of the dye laser generating in a wide band. If this same cuvette K is placed between the two mirrors of the laser (i.e., in the resonator of the laser), the spectrum of the laser radiation $P_2(\lambda)$ decreases by ΔI_2 corresponding to the absorption of the material (Figure 7.b). According to the experiments, ratio $\Delta I_2/ \Delta I_1$ (which specifies the sensitivity increase achieved by the absorption measurement in the resonator) can be of magnitude 10^3 to 10^5. The sensitivity increase is caused because the light beam passes through cuvette K several times before exiting from the laser. The laser phenomenon can be accurately understood by solving the differential equation system describing the functioning of the laser. The method is eminently suited for the qualitative and quantitative measurement of very low absorptions.[4]

III. 1. 2. Fluorescence Analysis

The large peak power of pulse-driven dye lasers and the application of phase-sensitivity detection methods improving the signal-to-noise ratio allow determining the extremely sensitive concentration based on fluorescence intensity measurements. For example, in our institute, we can perform reliable measurements of 10^{-12}mol/l dye concentrations by a tuned dye laser excited by an N_2 laser, as an excitation light source. However, there is a real opportunity to increase sensitivity further, since in our experiment the attainable sensitivity was defined by the purity of the chemical agent used.

During the measurement of atomic fluorescence, observations can be made in a narrow spectral range; thus, the signal-to-noise ratio can be improved by an order of magnitude. For example, we have managed to detect a flux of 10 atoms/s in line D_1 of Na by exciting with a continuous dye laser. Under experimental conditions, this corresponds to an Na atom created in laser beam number 10^{-4}.[3]

III. 2. High-Resolution Spectroscopy

Because of the Doppler effect, the absorption and emission frequency of moving particles differ from the transitional frequency of idle particles. During conventional spectroscopic measurements, the spectrum is formed by particles of various speed; thus the spectrum lines widen. The widening is usually much greater than the natural line width. Using tunable dye lasers, we developed several processes suitable for the resolution of the fine structures of the lines "smeared" by the Doppler widening. In the following, we shall describe the principle of so-called saturation spectroscopy.

The method is based on the so-called "hole-burning in Doppler distribution." To understand the system, let us consider a bilevel system struck by an $E \cos(\omega t - kx)$ plane laser wave (Figure 8).

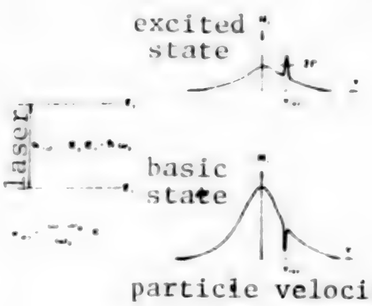

Figure 8. "Hole-Burning in Doppler Distribution."

From this plane wave, only those particles can be absorbed whose velocity, satisfies the following condition:

$$|\omega - \omega_0 + kv_x| \leq \Gamma \tag{5}$$

where Γ is the homogeneous width of the transition and v_x is the x velocity component of the particle. If the intensity of the laser light is sufficiently large, the distribution of particles satisfying condition 5 changes in such a manner that their concentration in the basic state decreases and in the excited state increases; i.e., saturation is achieved. Thus in the Doppler distribution, the laser beam "burns a hole" in the location corresponding to velocity $v_r = c(\omega - \omega_0)/\omega_0$. The diameter of the hole is determined by the homogeneous width of the line. The laser power necessary for the saturation is usually 10 mW.

Following saturation, the measurement of the homogeneous line width is reduced to the detection of the hole appearing in the population. A number of methods have been developed for this purpose, from which we shall describe the saturation spectroscopic method of an advancing wave. The experimental setup is shown in Figure 9.

Passing through the sample, the beam causing the saturation strikes a semitranslucent mirror, from where a small fraction of the beam--the so-called trial base--is reflected and arrives at the detector after passing through the sample again (Figure 9.a). The intensity of the trial beam is chosen to

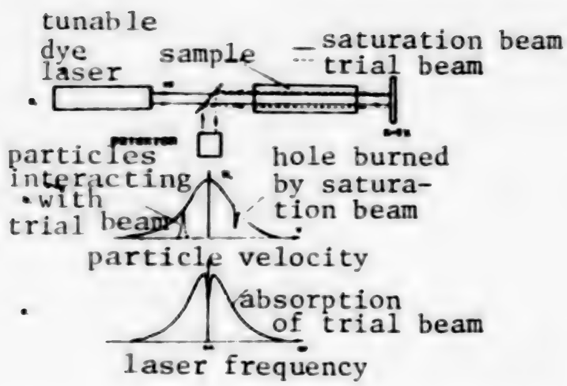

Figure 9. Advancing Wave Spectroscopy

be sufficiently low to ensure that it does not cause any further saturation. Since the direction of the trial beam is opposite to that of the saturation beam, it can only interact with those molecules whose velocity component in the direction of the saturation beam has magnitude v_r (Figure 9.b). If frequency ω of the laser agrees with frequency ω_0 of the transition, the trial beam interacts with those particles whose number in the state has already been reduced by the saturation beam; thus, tuning the dye laser, at frequency ω_0, a minimum quantity appears in the absorption, which corresponds to the homogeneous line width (Figure 9.c).

The advancing wave spectroscopic method is only one example of high-resolution spectroscopic methods in the Doppler line. For those wishing to become more familiar with the subject area, we recommend the monographs 2, 5, 8, 9, 10, 11.

III. 3. Increase in Time Resolution

The time resolution measurement method is a reliable gauge of the scientific potentials of a given epoch. Figure 10 illustrates the development of time resolution. The best resolution is about 0.2 ps; to comprehend fully what this means, it is enough to take into consideration that in 0.2 ps, in vacuum, light covers a mere 60 μ distance. The scientific significance of this type of measurement technology is hard to exaggerate.

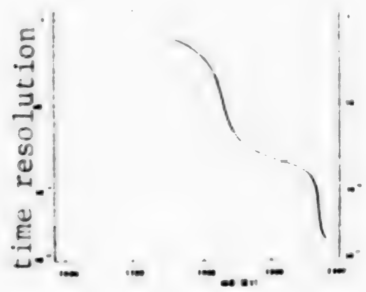

Figure 10. The Development of Time Resolution.

Dye lasers excited by N_2 lasers generate $\tau = (0.5 - 5)10^{-9}$ s duration light pulses. The life expectancy of atomic states and the fluorescence relaxation

time of organic dyes are usually longer than this; for that reason, by measuring the fluorescence decay generated by the dye laser, the life expectancy can be determined. The bandwidth of the available photodetectors, oscilloscopes and counters limit the resolution of these methods to 200 ps.

The appearance of so-called mode-synchronized dye lasers in 1968 caused a qualitative change in the development of time resolution. These lasers usually generate 0.2 to 10 ps long light pulses with 1 to 100 MHz repetition frequency. Since the registration of processes at these speeds cannot be performed at the present by electrical means, optical measurement methods have been developed. Three of these methods will be described.

III. 3. 1. Optical Kerr Gate

Figure 11 shows the setup used for the measurement of fluorescence decay. A Kerr gate is placed in front of the detector, in the path of the luminescence light excited by the picosecond laser pulse train; this gate consists of two

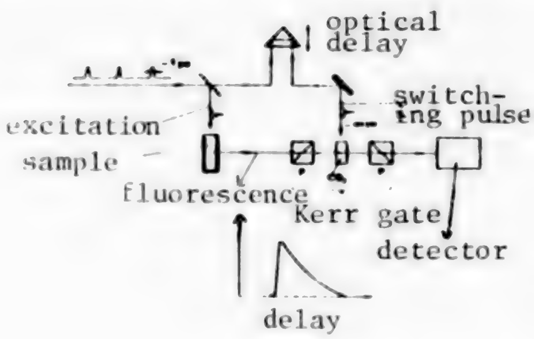

Figure 11. Kerr Gate for the Examination of Fluorescence Decay. The resolution of the setup is 2 ps.

cuvettes containing CS_2 and placed in crosspolarity. The gate lets the fluorescence light through only if the so-called switching laser pulse in the CS_2 causes optical double refraction. Thus, the Kerr gate is an optical lock open only for the time during which the switching pulse is present in the cuvette containing the CS_2. Varying the switching pulse delay, the fluorescence decay can be determined. The principle of the process is similar to the functioning of sampler oscilloscopes.

The length of gating is determined by the length of laser pulse and the relaxation time of the Kerr effect. The time resolution of the method may reach 2 ps.[8]

III. 3. 2. Absorption Saturation Method

Figure 12 shows the setup for the detection of rapid changes occurring in absorption.

From the picosecond pulse train, two collinear beams are formed, which are focused on the sample by the lens. The trial beam--whose intensity is a mere fraction of the exciter beam--serves for the detection of the absorption change caused by the exciter beam. The kinetics of the absorption change can be traced with the delay change of the exciter beam.

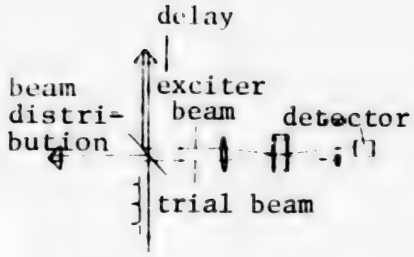

Figure 12. Setup for the Detection of Rapid Absorption Changes. The time resolution may reach 0.2 ps.

III. 3. 3. Transient Induced Grid Method

Figure 13 illustrates the principle of the method. The beam of the laser generating the picosecond pulse train is divided into three parts. From these, two beams generate interference in the sample. The excitation intensity periodically changes in space perpendicular to the direction of interference lines, which changes the complex refraction index of the sample; i.e., it slightly changes its refraction index or its absorption, corresponding to the spatial period of the excitation.

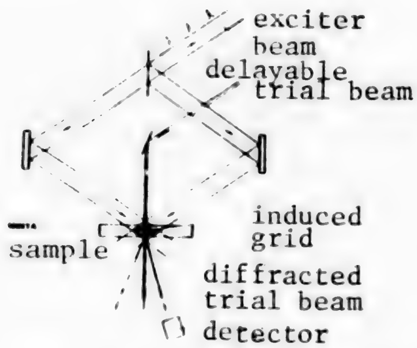

Figure 13. The principle of Transient Induced Grid Used for Measurement of Rapid Processes

This type of structure is called induced amplitude-phase grid. Passing through the sample, the third (the so-called trial) beam suffers diffraction. The intensity of the diffracted beam is proportionate to the modulation magnitude of the spatial refraction index of the induced grid. The relaxation of the induced grid (i.e., the relaxation of the phenomenon creating the amplitude-phase), can be traced with the delay of the trial beam. These three methods are successfully used for the examination of ultrahigh-speed physical, chemical and biological phenomena, such as the behavior of high-density plasma in semiconductors, the diffusion index and life-expectancy measurements of charge carriers and exitons, creation of photons and their relaxation, energy exchange between molecules, rotational relaxation, photodissociation, photochemistry, photosynthesis, oxygen absorption, the role of hemoglobin and rhodopsin in vision, DNA examinations, etc.

We recommend monograph 8 for those wishing to become more familiar with the subject.

III. 4. Application of the High-Power Density of Laser Radiation

By focusing the radiation of pulse-driven dye lasers, 10^9 to 10^{13} W/cm power density can be easily attained. Contrary to the experience of classical optics, the response is nonlinear under the influence of such a large power density. Here we mention only two of the numerous nonlinear effects.

III. 4. 1. Nonlinear Frequency Mixing

Polarization P, created in a medium by the effect of this electrical field strength, is described by the following power series:

$$P = \kappa E + \chi E^2 + \theta E^3 + \cdots \tag{6}$$

where κ, χ and θ are the first-, second-, and third-order dielectric susceptibilities of the material. Field strength is between 0.1 to 10 v/cm in beams used in classicial optics. In this case, the nonlinear members of the power series are negligible, and polarization is a linear function of the field strength. Field strength in laser beams, however, may reach values between 10^6 to 10^8 v/cm, which can be compared with the magnitude of the internal electric field of the crystal lattice. In this case, the high-order members cannot be ignored. Thus, if the medium is struck by an $E = E_0 \cos(\omega t - kx)$ harmonic plane wave, the generated polarization wave becomes anharmonic; i.e., it will also contain 2ω-, 3ω-, 4ω-, ··· frequency Fourier components, which means that a part of the negative frequency is converted to 2ω-, 3ω-, 4ω-, ··· frequency light. This phenomenon is called upper harmonic generation.

The medium must have strong nonlinearity for effective upper harmonic generation. This requirement is usually satisfied by ferroelectric materials, since polarization shows hysterisis even in the case of a 10^3 to 10^4 v/cm field strength. Hysterisis is an illustrative proof of nonlinearity. Another requirement of effective upper harmonic generation is wave synchronization, which means that the base harmonics of the frequency and the nth upper harmonics of the $N\omega$ frequency propagate at the same speed in the medium; i.e., the refractive index of the medium is identical at its base and upper harmonic wavelength. This requirement is usually not satisfied by the materials because of the dispersion of the refractive index. There are some anisotropic crystals in which, in a given direction, the extraordinary refractive index value at the nth upper harmonic wavelength agrees with the ordinary refractive index value at the basic harmonic wavelength. This direction is called the direction of wave synchronism.

The efficiency of upper harmonic generation may be as high as 10 percent with properly adjusted and high-quality crystals. KDP (KH_2PO_4), ADP ($NH_4H_2PO_4$) and $LiNbO_3$ crystals are used for semiharmonic generation. When nonlinear crystals are struck by laser light of frequency $\omega_1$and ω_2, the generated polarization wave also contains combinational frequencies ($2\omega_1$, $2\omega_2$, $\omega_1 + \omega_2$, $\omega_1 - \omega_2$). In the case of ω_1 and ω_2 components falling in the visible range, frequencies $2\omega_1$, $2\omega_2$, $\omega_1 + \omega_2$ fall in the UV range, while frequencies $\omega_1 - \omega_2$, in the IR range. If the laser radiation of frequency ω_1 or ω_2 is tunable, coherent UV or IR radiation may be produced, thereby facilitating the bandwidth expansion of spectroscopic methods.

III. 4. 2. Nonlinear Absorption; Excited-State Spectroscopy

Lambert-Beer's law (which specifies the exponential weakening of light) is valid when the population change caused by the light is negligible. The intensity of classical light sources is generally insufficient to change the equilibrium population significantly. Under the influence of a laser with as little as 10^5 to 10^6 W/cm power, half the molecules in the organic dye solution enter the excited state; thus, under the influence of beams with this great power, the solution transmission is nonlinear; i.e., it becomes a function of intensity and time. By measuring the nonlinear transmission, the transition probability values between the given levels can be determined. The high excitation power densities produced by the laser allow the direct measurement of absorption from the excited state. Figure 14 shows an experimental setup for this purpose.

One part of the N_2 laser beam produces excited states in the sample; the other pumps the dye laser. To determine the absorption spectrum of the excited state, the weakening of the dye laser beam must be measured twice: once with and once without excitation. The absorption spectrum of the excited states can be determined by tuning the dye laser and performing these two measurements at several wavelengths.[7]

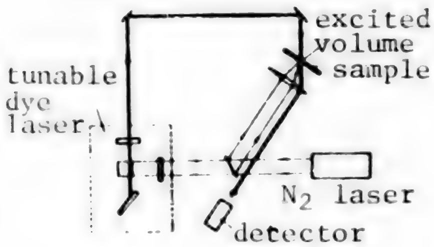

Figure 14. The Measurement Absorption From the Excited State.

In closing, we shall mention two nonspectroscopic applications.

III. 5. 1. Selective Photochemistry, Isotope Separation

With tunable dye lasers, atoms and molecules can be excited at a well-defined rotational and vibrational level of the electrone state; the gas-phase photochemical reactions can be accurately controlled. This offers the opportunity to synthesize pure and fundamentally new compounds. Isotope separation is an important practical branch of selective photochemistry. Below we describe the so-called two-stage ionization method.

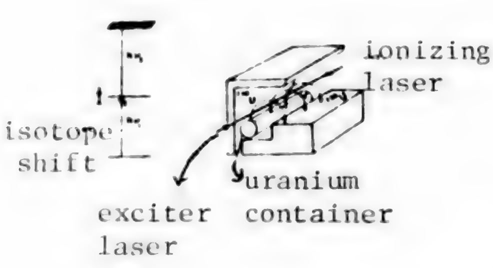

Figure 15. The Principle of Two-Stage Ionisation Isotope Separation

The corresponding isotopes of the atoms in the basic state are excited by a photon with energy $h\nu$, until they reach a state with strong isotope separation and ionize them with a photon of energy $h\nu_2$. This method assures that only one type of the isotope enters the ionized state. Then the ions are collected by an electric field.

To understand the significance of laser isotope separation, it is enough to consider the following: A 100-W average power laser produces approximately 6×10^{23} photons in 1 hour; the efficiency of the photochemical reactions approaches 100 percent; 6×10^{23} uranium atoms weigh 235kg. For those wishing to become more familiar with the chemical applications of lasers, we recommend the monograph 6.

III. 5. 2. Laser Microscope

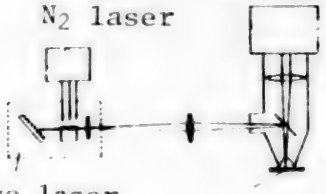

Figure 16. The Structure of a Laser Microscope.

Figure 16 illustrates a laser microscope used for fluorescence measurements. The beam of the tunable dye laser excited by an N_2 laser is focused on a given point of the viewing field of the microscope via suitably positioned optical elements. The fluorescence of the sample is registered by a high-speed light-emitting diode and a sampler oscilloscope. The equipment offers the following advantages:

a) A laser beam can be focused on as small an area as the resolution of the microscope; this permits the excitation of a given section of a cell and the examination of its fluorescence.

b) The excitation spectrum of the fluorescence can be recorded by tuning the dye laser.

c) Life expectancy can be determined by examining the fluorescence decay.

For those wishing to become more familiar with the chemical and biological applications of dye lasers, we recommend monograph 6.

With this, we close our summary, since the treatise calls for only a brief description of a few applications. Nevertheless, we hope that the treatise renders perceptible the qualitative change in optical spectroscopy caused by dye lasers.

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DETERMINATION OF BORON BY PROMPT NEUTRON ACTIVATION

Budapest MAGYAR FIZIKAI FOLYOIRAT in Hungarian Vol 29 No 6, 1981 pp 487-527 manuscript received 4 Aug 80

SZABO, S. ANDRAS, Provincial Food Testing and Chemical Testing Institute, Gyor (author's current affiliation: MEM [Ministry of Agriculture and Food, Main Education and Research Department)

[Abstract] This article is a summary of the author's candidate dissertation. It describes methods used at the Neutron Physics Laboratory of the Joint Nuclear Research Establishment in Dubna. The tests employ the IBR-30 pulse reactor and are based on the $^{10}B(n,\alpha)^{7}Li$ nuclear reaction. The boron concentration is measured with a Si detector having a surface barrier layer, by means of autoradiography, or by means of gamma spectrometry. The test procedures have all been published. The test specimens included ion implanted silicon wafers, metal glasses, biological specimens, and various other materials such as plant samples. The results were evaluated with BESM-4 and BESM-6 computers, using the spectrum devolution method for the determination of the surface boron concentration distribution. The results indicated that the actual measurable boron dose depends on the implantation energy (if the implantation energy is below 80 keV, the true dose is much lower than the dose measured electrically during implantation). Plants take up much more boron than they actually need if the nutrient solution contains more boron and the treatment time is lengthened. The boron is distributed in the plant in a non-uniform manner (maximum boron concentration was found in the leaf tips). The findings demonstrated that the boron moves in plants with the transpiration flow. The prompt neutron activation method is nondestructive and, since the ^{10}B isotope has a high effective cross section, boron can be determined at high sensitivity. Figures 24, tables 16, references 208: 66 Russian, 20 Hungarian, 14 German, 1 Polish, 1 Czechoslovak, 1 Japanese, and 105 Western.

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THE 300 CHANNEL CARRIER-FREQUENCY SYSTEM, TYPE BK-300/N, FOR SYMMETRICAL CABLE LINES

Budapest HIRADASTECHNIKA in Hungarian Vol 32 No 12, 1981 pp 461-468

PORPACZY, ELEMER, graduate electrical engineer, design engineer at TERTA-AFO [Telephone Factory]

[Abstract] The BK-300/N system can transmit 300 telephone channels in the four-wire, separate-frequency mode over a single cable. Each cable strand has a diameter of 0.9 mm, and is made of copper. The cable has an operating capacity of 38.5 nF/km. Transmission takes place through two strands; the other two strands are for service purposes. The line frequency of the system is made up of five main groups in the 312-1548 Hz band. The line-sector devices include the KEK-300/N combination amplifier frame, the NBK-300N remotely supplied and controlled amplifier, and auxiliary devices such as portable power supply and telephone, and crosstalk limiter. Terminal stations are available for the lower and the higher range of the frequency band. Remote supply takes place via the phantom circuit of the carrier-frequency circuits. There may be up to 38 remotely supplied intermediate amplifiers in the remotely controlled sector. The nominal distance between amplifier stations is 1,830 m if a 0.9 mm diameter paper-cordel insulated DM cable is used. Protection against overvoltage and interference is provided. The terminal station and the supervising central station may be supplied with AC from the utility or DC from a central supply. Major subassemblies (KEK-300/N terminal station, VVB-300/N terminator module, VTB line-transformer module, TTE-300/N remote-supply module, HB-4 fault-localizer module, SB-3 service module, LEB-3 branching module, LEB-3 branching module, and NBK-300/N remotely supplied remote-control amplifier) are described and illustrated with wiring diagrams. The system is highly reliable, permits the use of relatively short amplifier fields, allows the utilization of a relatively broad frequency range, and transmits information effectively. There is no need for cable compensation, and the system can be operated together with 12-channel systems operating over the same cable. This article is part of the BHG [Beloiannisz Communications Technological Factory] ORION Terta Reports]. Figures 10, no references.

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HIGHLY COMPLEX THICK-LAYER CIRCUITS WITH MONOLITHIC CIRCUIT CHIPS

Budapest FINOMMECHANIKA MIKROTECHNIKA in Hungarian Vol 21 No 1, Jan 82 pp 11-13

KOVESI, Andras, Remix Radio-Engineering Enterprise

[Abstract] This article is a report from Remix Radio-Engineering Enterprise. Development of circuits containing noncapsulated solid-state devices made by means of hybrid technology has been an ongoing activity at the enterprise since several years. The use of such circuits reduces the required space, increases the number of available connection points, reduces thermal resistance and improves heat dissipation, and provides economic benefits. The materials used for making these circuits include the paste (fritless gold pastes perform best), additives to reduce paste degradation, and conductor material (such as Heraeus L-HSB gold filament. The gold conductor is printed onto the ceramic substrate first. This is accomplished with a 325 mesh sieve. Then, insulating paste is printed where two or more conductors intersect. After heat treatment, the upper conductor layer, the resistor layers, and the solderable conductor layer are applied, and this is followed by the final heat treatment. The resistors are then adjusted, and the active and passive chips are mounted. The adhesive used to mount the chips is applied by screen printing, using an appropriate mask. Large passive components are mounted with tweezers; the active elements are mounted with mechanical devices, using a modified eutectic soldering device. The adhesive is finally crosslinked at 120°C. Two thermosonic machines are used for making the connections. Appropriate quality-control measures complete the procedures. Figures 3, references 6: 3 Hungarian and 3 Western.

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MODERN MEASURING TECHNIQUES FOR HYBRID INTEGRATED CIRCUITS

Budapest FINOMMECHANIKA MIKROTECHNIKA in Hungarian Vol 21 No 1, Jan 82 pp 21-25

KREMER, PETER, graduate computer engineer, Remix Radio-Engineering Enterprise

[Abstract] This article is a report from Remix Radio-Engineering Enterprise. The measuring techniques employed at Remix for quality control of hybrid integrated circuits are described briefly. The aim of the modern testing setup is to ensure that the equipment is easy to operate and convert from one model to another; that the measurements are fast, accurate, reliable, and reproducible; that all circuit parameters of interest are measured at a maximum possible degree of automation; that the results of the measurements are evaluated automatically; that a written protocol is issued on the measurements; and that the measurements are properly adapted to the manufacturing technology employed. Basically, the measurements made are resistance determinations and functional tests. The latter measurements may involve the determination of a variety of values such as voltage, current, frequency, distortion, gain, damping, and switching time. The following measuring systems are briefly illustrated: the Type 685 automatic setter with laser (Z 80 microprocessor, 10 kbyte program memory, 4 kbyte data memory, up to 39 resistors can be set or measured in one cycle (up to 19 if four-point measurements are made), value range 1 ohm to 100 Mohms, accuracy 0.02 percent or 0.05 percent (below 10 ohms and above 10 Mohms, respectively), programmable parameters: initial and final tolerance; location, geometric length, and type of the cut; positioning and cutting speed; laser output, and so forth), Type ATS-A121 analog test system, and PDV-24 programmable digital control unit. Computer-aided processing of the data is a prerequisite; a Siemens PC 100 small computer is used. Figures 11, references 5: 4 Hungarian and 1 German.

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ELECTRONICS AND ELECTRICAL ENGINEERING HUNGARY

ANALYSIS OF FACTORS AFFECTING THE CHARACTERISTICS OF NICKEL-CHROMIUM LAYERS

Budapest FINOMMECHANIKA MIKROTECHNIKA in Hungarian Vol 21 No 1, Jan 82 pp 7-10

NAGY, ISTVAN, Remix Radio-Engineering Enterprise

[Abstract] This article is a report from Remix Radio-Engineering Enterprise. It discusses the characteristics of NiCr resistor layers made by means of sublimation and the conditions for reproducible manufacture. Uniform temperature of the subliming filament is ensured by stabilizing the current, the voltage, and the length of the filament during sublimation. The composition of the resistor layer obtained is made up from the sublimed NiCr, the residual gas, and the impurities bound by gettering effects. By using a turbomolecular pump, the residual gas can be kept free of hydrocarbons. Reproducibility of the average Ni:Cr ratio of the resistor layer, the NiCr coverage, and the ohms per unit cross section can be ensured if the square resistivity fluctuates between 40 and 200 ohms per square mm. The aging sensitivity of these layers can be maintained within ± 2 percent. The reproducibility of the temperature coefficient cannot be achieved to such a close tolerance; the scatter of the values is wider. To obtain information concerning the performance characteristics of the resistor layer, we need information about layer composition, buildup rate, the final crystal structure, aging, and long-term stability. The composition of the pump oil affects the properties of the layer considerably. Figures 7, table 1, reference 1 (Hungarian)

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TECHNOLOGICAL ASPECTS OF THE DESIGNING OF THICK-LAYER RESISTANCE NETWORKS

KECSKEMETI, LAJOS, and SZETEI, TIBOR, Remix Radio-Engineering Enterprise

Budapest FINOMMECHANIKA MIKROTECHNIKA in Hungarian Vol 21 No 1, Jan 82
pp 1-6

[Abstract] This article is a report from Remix Radio-Engineering Enterprise. It discusses the factors determining the performance of resistors found in circuits made by means of thick-layer hybrid technology, and a new method for the evaluation of the resistance pastes used. The method of evaluation uses an evaluation board prepared with the RONDEC SCFRI circuit-printing apparatus, accommodated on a 2" by 2" substrate, employing a SOLARTRON Type 7065 microprocessor-based multimeter. The data obtained are processed with a SIEMENS PC 100 benchtop computer. The simple program used provides the mean resistivities, standardized resistivities, scatter, and the modified L/D (shape factor) values. The equipment also features a test-point selector and may be used in conjunction with the appropriate peripheral devices for data storage and further processing according to other considerations. The main goal of the evaluation and processing of the measurement results was to obtain tables and diagrams which can be incorporated in the designing process directly, which contain specific values, and provide maximum possible information of the paste characteristics. It was also expected that the information permits the checking of the settings of the technological parameters. The method provides a data set describing the effects of geometric factors on the characteristics of the paste, so that a regression function adapted to the points is obtained. As a result, it is possible to determine in advance the manner in which a paste from a supplier must be matched to the technological resistance-network manufacturing parameters, and whether the paste conforms to the specifications of the manufacturer and the user. Figures 7, table no references.

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THE TYPE COMBI-X HIGH-CAPACITY TELEPHONE EXCHANGE

Budapest HIRADASTECHNIKA in Hungarian Vol 33 No 2, 1982 pp 73-78

CZOBOR, MIKLOS, graduate electrical engineer, technical and economic advisor of BHG [Beloiannisz Communications Engineering Factory] Development Institute

[Abstract] The COMBI-X high-capacity telephone exchange is still under development. This article, part of BHG ORION TERTA [Telephone Factory] Reports, discusses the services and operation of the exchange. The exchange, as its name indicates, can perform subexchange and main-exchange functions. In terms of system engineering and construction, it is a unit in the AR type telephone exchange family; actually it is a version of the main exchange ARF102 extended for subexchange capabilities. The subexchange sector provides as basic services those which are normally performed by a subexchange, and can be extended for additional such services, without affecting the performance of the exchange as a main exchange. The result is that both secondary subscribers and main stations can be connected. The system uses the MFC signaling method, so that with the postal facilities, which use the same method, even a national network can be set up. Because of the flexible register organization, it can operate in conjunction with other exchanges (for example rotary types) at the group selection level. Since the COMBI-X can be operated as a subexchange (manual operator control), as a centrex exchange (jointly used by several institutions) and main exchange (for main stations), it can handle subscriber and public telephone functions in office buildings used by several insti-turions (both inside and local or long distance conversations), and permits the efficient utilization of the equipment of the telephone central system in peak demand periods. The basic and optional services and operating characteristics of the system are briefly described. Figure 1, no references.

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ELECTRONICS AND ELECTRICAL ENGINEERING HUNGARY

CONCURRENT PASCAL FOR KERNEL MULTIMICROPROCESSOR

Budapest INFORMACIO ELEKTRONIKA in Hungarian No 1, 1982 pp 3438 manuscript received 17 Jul 81

KACSUK, Peter: GROF, JOZSEF; and HINCS, SANDOR

[Abstract] A microprocessor-based device was recently developed at Videoton for process control. The real-time operating system running on it (multimask monitor) effectively distributes the processor among the concurrent processes, synchronizes concurrent processes with the aid of event variables, and handles the power source via semaphors. Although it performs very effective services, the writing of large concurrent programs is tedious and insufficiently dependable without the use of a high-level programming language. In attempting to select such a language, the CONCURRENT PASCAL was found to be the most suitable. It ensures structured program designing and writing not only for sequential but also for concurrent programs, its monitor concept enables the translator program to check during the translation time the communication of the concurrent processes, and provides the proper method for inherent and divided data structures. To adapt the CONCURRENT PASCAL to the intended purpose, the syntax and the translation method was left intact, only the interpreter and the kernel were modified as required for forming the multimicroprocessor. Figures 3, references 5: 1 Western and 4 Hungarian.

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